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March 25, 2011

Pedro J. Nieves Miranda, Esq.
President
Puerto Rico Environmental Quality Board (PREQB)
Edificio de Agencias Ambientales Cruz A. Matos
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RE: Response to Community Concerns about AGREMAX™

Dear Mr. Nieves:

AES Puerto Rico (AES-PR) appreciates this opportunity to provide information on AGREMAX™ and other products to the Puerto Rico Environmental Quality Board (PREQB) to help inform your development of guidelines for the beneficial use of coal combustion products (CCPs) in Puerto Rico.

Per your letter request of January 21, 2011, AES-PR is submitting available data regarding the levels of radionuclides in AES-PR raw material, in-process material, and AGREMAX™. Available data for other materials as well as other inorganic constituents have also been included. The AES-PR data are reported in Attachment A. This letter also responds to the concerns of the community group and Drs. Aponte and Rosario regarding the use of AGREMAX™ based on their sampling, and reports the results of several new samples collected by AES-PR for comparison to the community group data (Attachment B). Attachment C provides additional relevant information.

**AES Puerto Rico**

The AES-PR facility is a 454.3 net megawatt circulating fluidized bed (CFB) boiler coal-fired power plant located in Guayama, Puerto Rico. This plant is a state of the art facility. It is one of the world's cleanest power plants and Puerto Rico's first zero discharge facility. AES-PR provides 15% of Puerto Rico's energy consumption, supplying power to the Puerto Rico Electric Power Authority (PREPA).

**AES-PR CCP Beneficial Use Program**

As part of the AES-PR-commitment to the environment, we agreed with PREPA in our Power Purchase Agreement (PPA) to ensure that 100% of our CCPs were put into beneficial use. This agreement obviates the need for a CCP disposal facility on the island. We have partnered with the University of Puerto Rico at Mayaguez (UPRM) and other academic institutions to research and develop environmentally and scientifically sound beneficial uses for the CCPs we produce. AES-PR has supported a number of independent research projects; the most significant of these led to the development of AGREMAX™, a lightweight manufactured aggregate made entirely of recycled materials that is used in the construction industry for structural fill and for transportation projects as a base for

highways, rural roads, and parking lots as well as a replacement for raw materials in the production of concrete.

AES-PR also supports the research into other uses of their CCPs and has placed these materials into beneficial use for liquid waste stabilization, agricultural uses for soil amendment and improvement, and uses in the asphalt and roofing industries.

These uses of AES-PR CCPs have benefits beyond the specific tangible projects; their use saves energy and impacts on the environment associated with the mining, refinement and transportation of the virgin raw materials that would otherwise be needed for these projects, offsetting greenhouse gas emissions that would otherwise be incurred by the processing of virgin materials. In addition, AGREMAX™ and our other CCP products are less expensive than alternative materials, thus providing an economic benefit for on-island development projects, especially in economically challenged rural areas. Our facility employs 110 workers, and our business contracts for CCP beneficial use provide a boost to the local economy, creating hundreds of direct and indirect jobs.

Our research into environmentally beneficial uses for CCPs has garnered awards within government and the industry. AES-PR received 1st Place for Environmental Innovation for the innovative marketing strategies of CCP's and 2nd Place for Environmental Leader for the leadership exhibited on the collaboration with the Puerto Rico Construction Cluster and the University of Puerto Rico for CCP research projects. The University of Puerto Rico at Mayaguez received an award from the United States Environmental Protection Agency's Coal Combustion Products Partnership (C2P2). The awards were presented at the National Recycling Conference and Expo held in Atlanta, Georgia on October 23, 2006. The award was presented based on the previously completed research project "Potential Applications for AES-PR Coal Combustion Products."

**Available Analytical Information for AES-PR CCPs**

As part of our stewardship program, AES-PR has conducted a program for sampling and analytical testing of its materials and products.

AES-PR has contracted with AECOM Environment, a global provider of professional technical and management support services to a broad range of markets, to conduct this evaluation. AECOM staff specializing in data validation and data evaluation, including human health risk assessment and health physics, has provided their technical expertise for this project. AECOM staff, under the leadership of Dr. Lisa Bradley, Vice-President and Senior Toxicologist for AECOM, has worked closely with AES-PR staff to prepare this letter report for the PREQB.

AES-PR has collected samples of the following materials for laboratory analysis:

- Fly ash – AES-PR
- Bed ash – AES-PR
- Ash rock (AGREMAX™) – AES-PR
- Coal – AES-PR (sourced from Colombia)
- Native road bed material (where AES-PR AGREMAX™ has not been used)
- Cement (not made with AES-PR fly ash)

Analytical data are available for Toxicity Characteristic Leaching Procedure (TCLP) (initially for the full analyte list, and subsequently for metals only, based in the initial results); metals analyses, gamma spectroscopy, and isotopic thorium by alpha spectrometry. Data validation was conducted on all samples (following U.S. Environmental Protection Agency (USEPA) Contract Laboratory Program (CLP) National

Functional guidance and the U.S. Department of Energy (USDOE) Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)). No sample results were rejected in the validation process and it was concluded that in general the data appear to be valid as reported and may be used for decision-making purposes. The validated data are provided in Tables 1 through 4 in Attachment A.

In addition to the data discussed above, soil samples were collected in 1995 and were analyzed for metals, prior to the construction of the facility. These samples represent local background and are reported in Attachment A, Table 4.

**Evaluation of the AES-PR Analytical Data**

Data for Radionuclides for AES-PR Materials and Products

Figure 1 presents graphs comparing the radionuclide results for samples of AGREMAX™, AES-PR fly ash, and AES-PR bed ash. The AGREMAX™ results are compared to results from samples of native road bed. A simple human health risk-based comparison is provided. The sample results are compared to Preliminary Remediation Goals (PRGs) developed by USEPA for radionuclides in a residential and an industrial/commercial soil setting [http://epa-prgs.ornl.gov/radionuclides/ ]. To provide a conservative comparison, the PRGs represent the activities in soil to which a resident (adult/child) or a worker can be exposed to on a daily basis without exceeding a cancer risk level of $1x10^{-6}$. Note that this is conservative because the USEPA target risk range is $1x10^{-6}$ to $1x10^{-4}$. Thus the PRGs as presented in Figures 1 and 2 could be 100-fold higher and still protective of human health. The radionuclides included on the graphs are the few that were detected out of the more than 40 radionuclides analyzed.

As indicated in Figure 1, the majority of radionuclide activities in AGREMAX™, AES fly ash, and AES bed ash are consistent with data from the background soil samples, and below the PRGs for a residential exposure scenario, a scenario that assumes that all incidental soil exposure by a residential adult/child is to these materials. The exceptions are the potassium-40 (K-40) and radium-226 (Ra-226) activities in these samples. The Ra-226 activities are consistent with background and both are slightly above the residential PRGs at the $1x10^{-6}$ level, but well below the residential PRG at a $1x10^{-4}$ level. The K-40 activities are consistent with background and both are above the residential PRGs at the $1x10^{-6}$ level, but also well below the residential PRG at a $1x10^{-4}$ level. Thus, these activities are within the USEPA's target risk range.

As indicated in Figure 2, the majority of radionuclide activities in AGREMAX™, AES-PR fly ash, and AES-PR bed ash are generally consistent with background soil and are below the PRGs for an industrial/commercial exposure scenario, a scenario that assumes daily exposure on a work-day basis. The exception is K-40 activities in these samples, as well as background, which are slightly above the commercial/industrial PRG at the $1x10^{-6}$ level, but well below the PRG at a $1x10^{-4}$ level.

The following tables present a summary of the K-40 and Ra-226 activities in AES-PR ash samples, the road bed and cement samples analyzed by AES-PR, and activities for naturally occurring materials. As can be seen the AES-PR results are similar to or below the activities of these other materials.

| K-40 (pCi/g) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Road Bed | Cement | Igneous Rock | Sandstones | Limestones | Red Brick | Central Indiana Clay | Fill Sand |
| AES-PR Ash (a) | | (b) | (b) | (c) | (c) | (c) | (d) | (d) | (d) |
| Max | 9.8 | 4 | 3.38 | 22 | 8.8 | 2.2 | 61.83 | 30.83 | 20.12 |
| Min | 2.2 | | | | | | | | |
| 95% UCL | 10.9 | | | | | | | | |
| 95% LCL | 1.9 | | | | | | | | |
| Mean | 6.4 | | | | | | | | |

| Ra-226 (pCi/g) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Road Bed | Cement | Igneous Rock | Sandstones | Limestones | Red Brick | Central Indiana Clay | Fill Sand |
| AES-PR Ash (a) | | (b) | (b) | (c) | (c) | (c) | (d) | (d) | (d) |
| Max | 2.85 | 0.6 | 1.81 | 1.3 | 0.71 | 0.42 | 2.75 | 1.89 | 1.05 |
| Min | 1.38 | | | | | | | | |
| 95% UCL | 3.5 | | | | | | | | |
| 95% LCL | 0.5 | | | | | | | | |
| Mean | 2 | | | | | | | | |

Notes:
LCL - 95% Lower Concentration Level.
UCL - 95% Upper Concentration
Level.
(a) Results are summarized for AESR fly ash, bed ash, and ash rock (AGREMAX™).
(b) Collected and analyzed by AES-PR. Did not contain AES-PR ash.
(c) Eisenbud, Merril. 1987. Environmental Radioactivity From Natural, Industrial, and Military Sources. Third Edition. Academic Press, Inc. San Diego, CA. 1987.
(d) INDOT. 1998. Identification and Quantification of Radionuclides in Coal Ash. Indiana DOT Report FHWA/IN/JTRP-98/01.

To provide some everyday context to these K-40 results, Figure 3 compares the K-40 activities in AES-PR AGREMAX™, AES-PR bed ash, AES-PR fly ash, and cement to a variety of naturally occurring materials, as well as to foodstuffs to which we can be exposed on a daily basis. Foods naturally high in potassium are also naturally high in K-40, for example, bananas and Brazil nuts. Table salt substitute is made of potassium chloride (KCl), which is available in the grocery store and is used by people who are controlling their intake of table salt (sodium chloride or NaCl). Note that all the materials presented have activities of K-40 that exceed the residential PRG of 0.116 pCi/g.

TCLP analyses were conducted on these samples, mainly analyzed for metals, but Ra-226 was also analyzed in a subset of samples. The data in Table 2 of Attachment A indicate non-detect results for ash rock, bed ash, and fly ash, and very low concentrations of Ra-226 (0.66 and 1.81 pCi/L) in coal and road bed samples. These levels are below the USEPA drinking water standard of 5 pCi/L [http://water.epa.gov/action/advisories/drinking/upload/dwstandards2009.pdf ].

Metals Analyses of AES Materials and Products

Figure 4 presents graphs comparing metals results of samples of AGREMAX™, AES-PR fly ash, and AES-PR bed ash to background levels in soils as measured at the location of the AES-PR facility prior to its construction. These levels are compared to the USEPA residential soil Regional Screening Levels (RSLs) [http://www.epa.gov/region9/superfund/prg/index.html]. As with radionuclide PRGs, residential soil RSLs are calculated based on a residential scenario and represent the concentration in soil to which

a residential receptor could be exposed on a daily basis without exceeding a cancer risk level of $1x10^{-6}$ or a noncancer hazard index of one. Note that this is conservative because the USEPA target risk range is $1x10^{-6}$ to $1x10^{-4}$. For many of the metals, the AES-PR materials exhibit concentrations that are within the range of the background soil results. With the exception of arsenic and chromium, concentrations present in the AES-PR materials are below residential soil RSLs. Figure 4 plots the RSL for arsenic at the $1x10^{-4}$ risk level. The concentrations of arsenic in AGREMAX™, AES-PR fly ash, and AES-PR bed ash are slightly above the RSL. For chromium, it should be noted that the RSL used in this evaluation is for hexavalent chromium at the $1x10^{-4}$ risk level, which assumes that the chromium present in these materials is in the hexavalent form, which is unlikely. The AES-PR materials have concentrations well below the RSL for trivalent chromium of 120,000 mg/kg. Information on other CCPs indicates that the hexavalent chromium content of coal ash is low, constituting approximately 1% of total chromium [see http://www.epa.gov/region5/sites/pines/pdfs/pines_ri_201003_tables.pdf - Table 2-2]. Also note that the total chromium concentrations in the TCLP leachates were very low (approximately <10 ug/L where detected).

**Figure 5** presents graphs showing TCLP results for metals from samples of the AES-PR materials. The TCLP concentrations of the AES-PR materials are below the maximum allowable TCLP concentrations for hazardous waste characterization (40 CFR Part 261).

**Evaluation of the Gross Alpha and Beta Spectroscopy**

As discussed in your January 21, 2011 letter, a community group provided radioanalytical information on material purported to be AGREMAX™. These data are discussed below. Because of our concerns with their methods, AES-PR has undertaken a similar evaluation of their materials, and these data are also presented.

Information Supplied by Drs. Aponte and Rosario

As discussed in your January 21, 2011 letter, a community group collected a sample where they believed the manufactured aggregate was used as structural fill material. Because AES-PR was not involved in this sampling and detailed information regarding where and how the sample was collected was not provided, AES-PR cannot verify whether the material sampled contained AGREMAX™.

Gross alpha and gross beta analyses were conducted on soil/solid sample number 680-60518-01 collected on August 18, 2010. The sample was analyzed by KNL Laboratory Services in Tampa, Florida on August 31, 2010 by DOE Method RP710, Gross Alpha and Beta Activity. This method rapidly screens a variety of matrices for both high and low activities of alpha and beta emitting radionuclides in waters, air filters, soils, sludges, wastewaters, and solvents.

The results of the sample analyses were reported as follows:

- Gross Alpha 9.9 ± 1.6 pCi/g (0.37 ± 0.06 Bq/g)
- Gross Beta 5.7 ± 0.8 pCi/g (0.21 ± 0.03 Bq/g)

Screening levels for residual levels in soil are not available for gross alpha and gross beta. However, the International Atomic Energy Agency (IAEA) has provided a total activity screening level of 0.5 Bq/g (13.5 pCi/g) for natural thorium and/or uranium (Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No.115, IAEA Vienna, 1996). The combined gross alpha and gross beta activity, which would not only include natural uranium and thorium but also potassium-40, slightly exceeds the 0.5 Bq/g (13.5 pCi/g) screening level indicating that further investigation is likely not warranted.

AES-PR Sampling Results

AES-PR collected samples of several materials and submitted them for analysis of gross alpha and gross beta radiation. Samples were collected on February 22, 2011 by AES-PR personnel, and submitted to two laboratories for gross alpha and gross beta activity determination: KNL Laboratory Services, Inc., Tampa, FL; and ALS, Environmental Division, Fort Collins, CO. Testing was conducted using method DOE RP710 or equivalent (EPA 900.0 modified for soil matrix). The results are reported in Attachment C, including the data validation, and are summarized below; for comparison purposes, the results for the community group sample are also shown.

| Sample ID | ALS Results pCi/g | | | | | | | KNL Results pCi/g | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gross Alpha | | | | Gross Beta | | | Gross Alpha | | | | Gross Beta | | |
| | Result | | TPU | Flag | Result | | TPU | Flag | Result | | TPU | Flag | Result | | TPU | Flag |
| AESPR Coal Sample | 0.98 | +/- | 0.64 | | 1.01 | +/- | 0.66 | U | 5.7 | +/- | 1.6 | | 4.1 | +/- | 0.8 | |
| Cement Sample | 3.2 | +/- | 1.5 | | 4.2 | +/- | 1.8 | | 36 | +/- | 15 | | 8.5 | +/- | 1.3 | |
| AESPR Limestone Sample | 1.1 | +/- | 1.1 | U | 1.4 | +/- | 1.6 | U | 11.5 | +/- | 3.5 | | 1.8 | +/- | 0.9 | U |
| AESPR Fly Ash Sample | 4.9 | +/- | 1.6 | | 8.4 | +/- | 2.3 | | 33 | +/- | 5 | | 17.1 | +/- | 1.7 | |
| AESPR Bed Ash Sample | 6.2 | +/- | 1.8 | | 4.4 | +/- | 1.8 | | 70 | +/- | 1 | | 12.9 | +/- | 1.2 | |
| AESPR Agremax Sample | 8.1 | +/- | 2 | | 8.7 | +/- | 2.3 | | 14.7 | +/- | 3.7 | | 10.1 | +/- | 0.9 | |
| Salinas Soil Sample | 0.26 | +/- | 0.87 | U | 3.3 | +/- | 1.5 | | 1.7 | +/- | 1.7 | U | 9.5 | +/- | 0.9 | |
| Santa Isabel Soil Sample | 2.6 | +/- | 1.5 | | 5.1 | +/- | 1.8 | | 0.5 | +/- | 0.2 | | 1.2 | +/- | 0.1 | |
| Guayama Soil Sample | 1 | +/- | 1 | U | 2.2 | +/- | 1.4 | U | 5.4 | +/- | 1.8 | | 7.1 | +/- | 0.9 | |
| Arroyo Soil Sample | 0.65 | +/- | 0.91 | U | 2.9 | +/- | 1.4 | | 13.5 | +/- | 3.4 | | 6 | +/- | 0.7 | |

Notes:
ALS, Fort Collins, CO.
KNL, Tampa, FL.
pCi/r - picoCuries per gram
TPU - total propogated uncertainty
U - sample result not detected at the reported level of detection

While the results from each laboratory are different, they are internally consistent, and indicate that the AGREMAX™ results are slightly above the results for native soils in the area; however, the isotopic analysis presented above indicates that this is not of concern. The AGREMAX™ results are similar to the results from a bag of cement taken "off the shelf"; the results are also consistent with those reported by the community group. Note that the results for fly ash and cement are also similar.

The differences in the magnitude of the results between the laboratories are likely due to several factors. First, these are heterogeneous materials that are being sampled, and the laboratories take small aliquots for counting, thus these aliquots are not the same between laboratories. Second, the laboratories are using different alpha and beta counting standards that have different counting efficiencies; this accounts for the differences in the overall magnitude of the results. And finally, because of the very general, nonspecific nature of this type of testing, gross alpha and beta analyses like these are considered preliminary at best. As noted above, a general screening level for these types of results is 13.5 pCi/g. The screening level is meant to be used only to indicate if further evaluation is warranted. The ALS laboratory results would indicate that no further evaluation is needed, however the KNL laboratory results would be indicative of further evaluation. AES-PR has the more appropriate, detailed isotopic analyses, the results of which have been discussed above.

Therefore, these results when taken together with the more detailed radionuclide results indicate that there is no need for concern for the beneficial use of CCPs or AGREMAX™ on the island.

**Radiation Risks in Perspective**

While a number of concerns have been raised regarding the use of CCPs in various materials due to potential radioactivity and other substances that may be present, available data and current research do not support these concerns.

The United States Geological Survey (USGS) prepared a fact sheet (USGS Fact Sheet FS-163-97) to summarize information regarding radioactive elements in coal and fly ash (Attachment C). The fact sheet concludes that:

> "Radioactive elements in coal and fly ash should not be sources of alarm. The vast majority of coal and the majority of fly ash are not significantly enriched in radioactive elements, or in associated radioactivity, compared to common soils or rocks. This observation provides a useful geologic perspective for addressing societal concerns regarding possible radiation and radon hazard."

Potential exposure to radioactive materials in CCPs, including those present in AGREMAX™, is within the range of background exposure to radionuclide-containing materials in everyday life. Table 1 presents potential exposure to a number of common materials. Table 1 also provides a literature estimate of the potential radiation dose to a worker assumed to be exposed to these materials on a daily basis. The potential radiation dose is 10-fold lower than a conservative estimate of background radiation dose for residents of Puerto Rico.

**Summary**

AES-PR thanks you again for this opportunity to provide this information to the PREQB. In summary, the data demonstrates that the allegations by Drs. Aponte and Rosario that harmful radiation levels can result from the use of AGREMAX™ have no merit. Taken together, these results indicate that the use of AES-PR CCPs in beneficial use projects would not have an adverse impact on either human health or the environment. While we understand that community members may be concerned, we hope that by working with the PREQB and providing this complete and comprehensive evaluation we can allay those fears. If you have any questions, or would like to discuss these matters further, please do not hesitate to call me at 787-866-8117 x 2212.

Sincerely,

Allan B. Dyer
President

Cc: Eng. Carl-Axel P. Soderberg, Director USEPA Region II CEPD

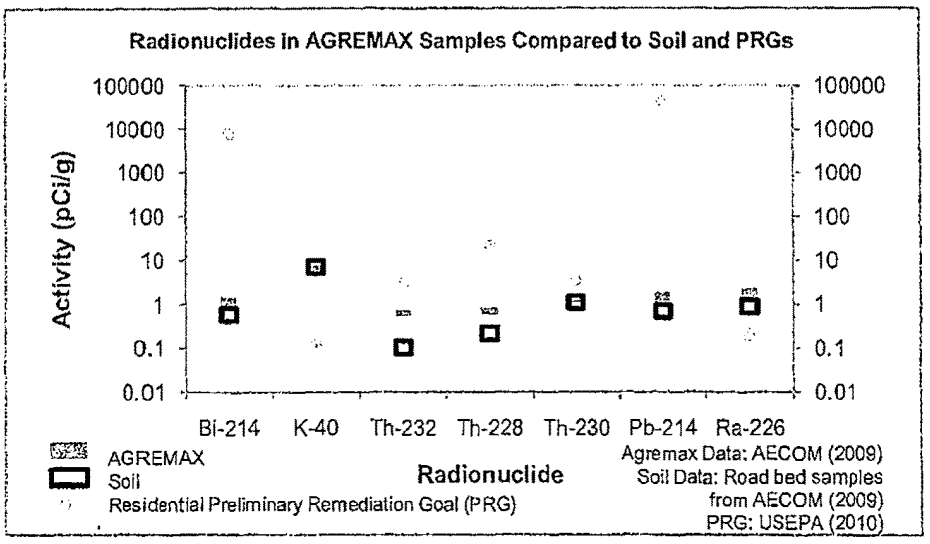
**Table 1**
**Common Exposures to Radiation**

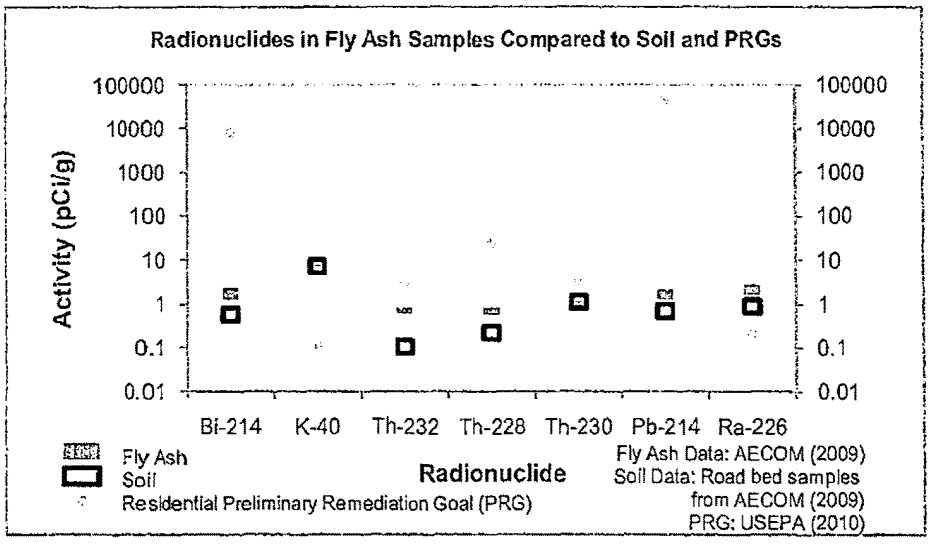
| Everyday Exposures (a) | Dose (mrem/yr) |
|---|---|
| **Medical Treatment** | |
| Chest x-ray | 10 (b) |
| Dental x-ray | 100 (b) |
| **Consumer goods** | |
| Cigarettes - 2 packs/day | 8000 |
| Color Television | <1 |
| Phosphate Fertilizers | 4 |
| Porcelain Dentures | 1500 |
| Smoke Detector | 0.01 |
| **Food** | |
| Dietary Contributions | 20 |
| **Buildings** | |
| Statue of Liberty | 325 |
| Grand Central Station | 525 |
| The Vatican | 800 |
| **Travel** | |
| Airplane Travel | 0.5 |
| **Terrestrial Radiation** | |
| Average terrestrial radiation in U.S. cities | 26 |
| Estimated background dose for Puerto Rico (c) | 293 |
| **Miscellaneous** | |
| Highway Construction | 4 |
| **Exposures from Coal Ash** | |
| Average Worker Exposure to Fly Ash (d) | 25.90 |
| Average Worker Exposure to Bottom Ash (d) | 18.10 |

Notes:
(a) - Everyday exposures obtained from http://www.fusrapmaywood.com/factsheet/radenv.htm; a website maintained by the US Army Corps of Engineers.
(b) - Dose (in millirem or mrem) is calculated per x-ray.
(c) - Estimated background dose for the Puerto Rico was estimated using USEPA's Radiation Calculator (http://www.epa.gov/rpdweb00/understand/calculate.html) employing the default (conservative) options, e.g. no air travel, no medical x-rays, no medical MRIs, and no exposure to building materials.
(d) - INDOT. Identification and Quantification of Radionuclides in Coal Ash. Indiana DOT Report FHWA/IN/JTRP-98/01. Based on 2000 hr work year. [8 hours/day for 250 days/year]

# Figures

Figure 1
Comparison of Radiologicals In Soil and Ashes to Residential PRGs
AES Puerto Rico, LP
Guayama, PR



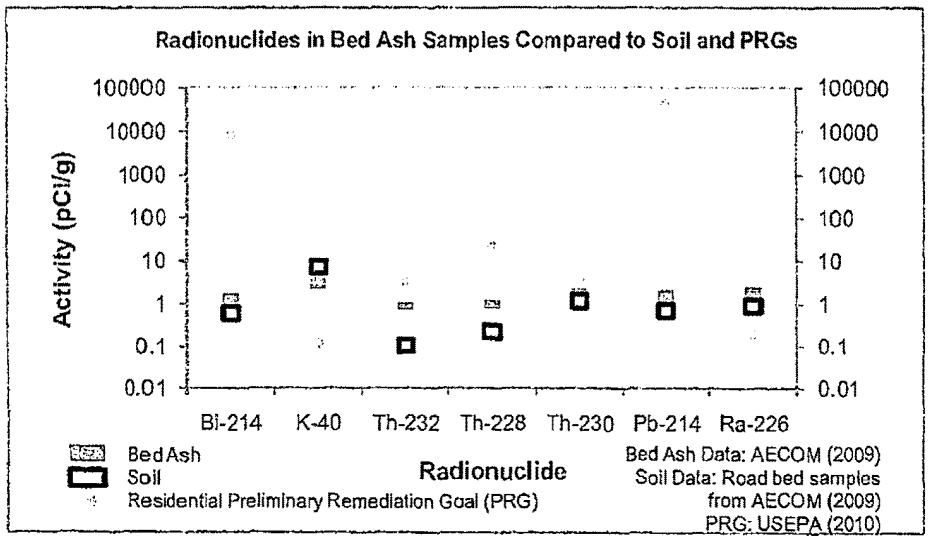
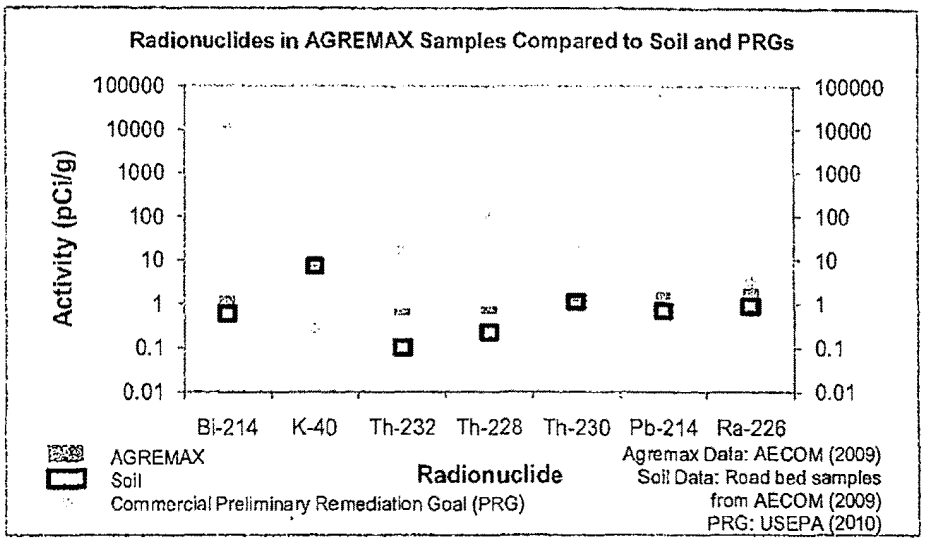
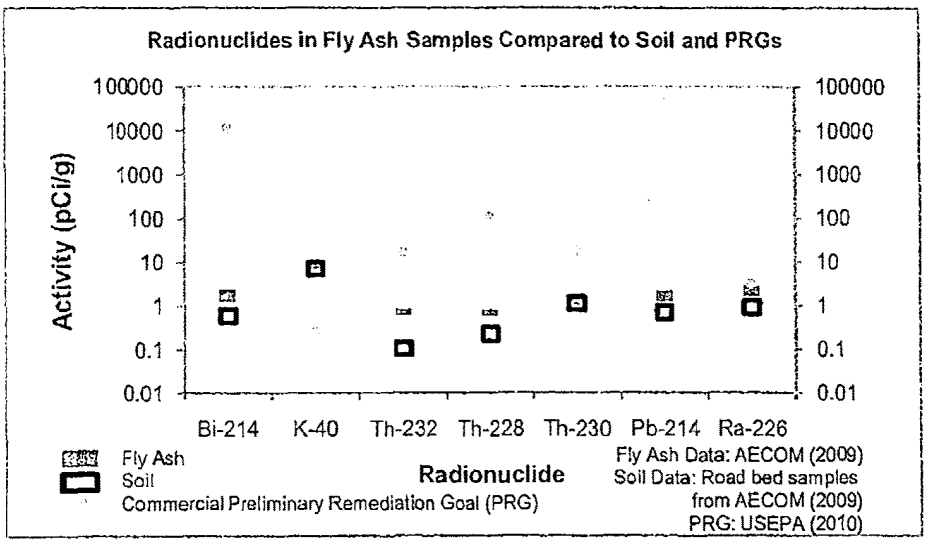



Figure 2
Comparison of Radiologicals in Soil and Ashes to Commercial PRGs
AES Puerto Rico, LP
Guayama, PR



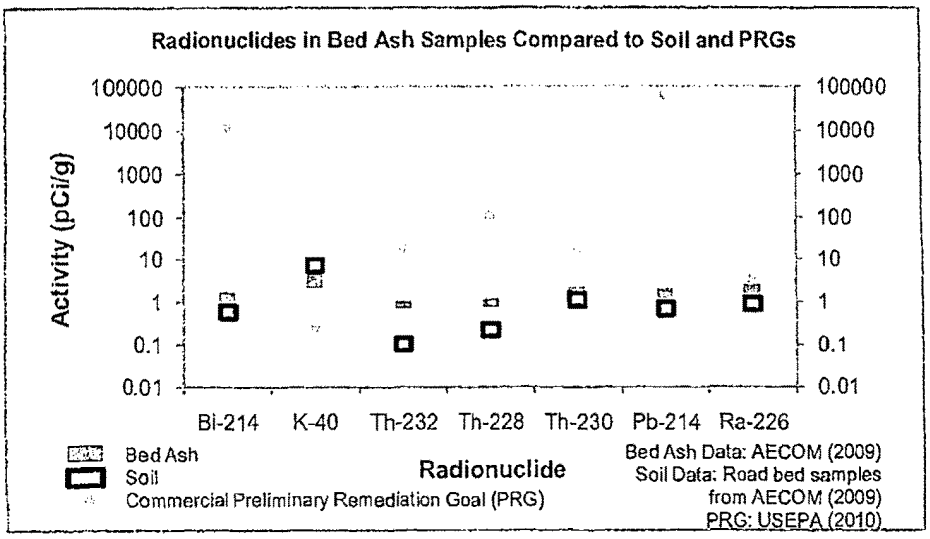
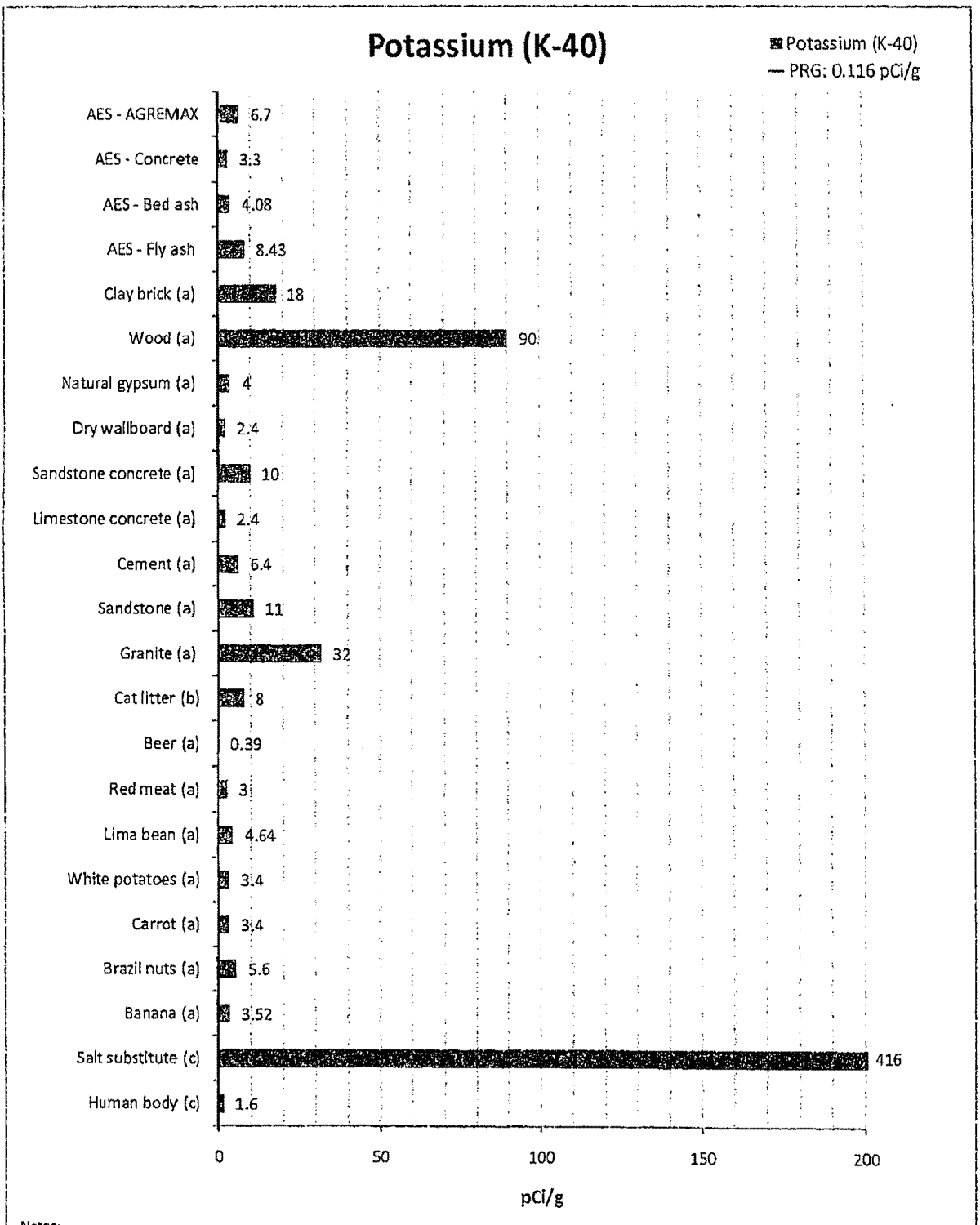
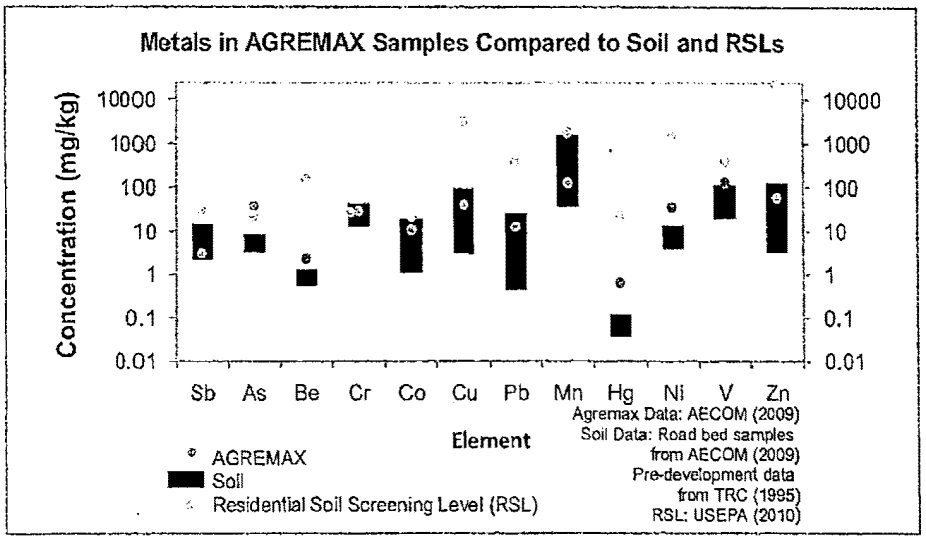



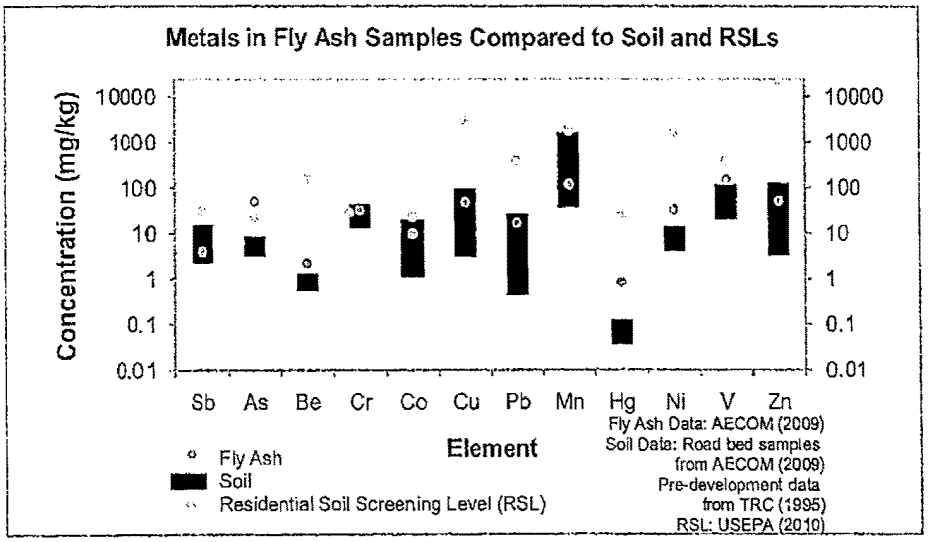
Figure 3
Levels of K-40 in Ashes and Other Natural Materials
AES Puerto Rico, LP
Guayama, PR




Notes:
Preliminary Remediation Goal (PRG) for K-40 for Residential Soil. August 3, 2010. http://epa-prgs.ornl.gov/radionuclides/download.shtml
(a) Radiation Risk - A Critical Look at Real and Perceived Risks from Radiation Exposure. Phil Rutherford. August 12, 2002. [URL: http://www.philrutherford.com/Radiation_Risk/Radiation_Risk.pdf]
(b) Oak Ridge Associated Universities. 2009. Radioactive Consumer Products - Cat Litter. [URL: http://www.orau.org/ptp/collection/consumer%20products/catlitter.htm]
(c) Ramme, B.W. and Tharaniyil, M.P. We Energies Coal Combustion Products Utilization Handbook. Copyright © 2004 Wisconsin Energy Corporation. 278 pp.

Figure 4
Comparison of Metals in Soil and Ashes to RSLs
AES Puerto Rico, LP
Guayama, PR



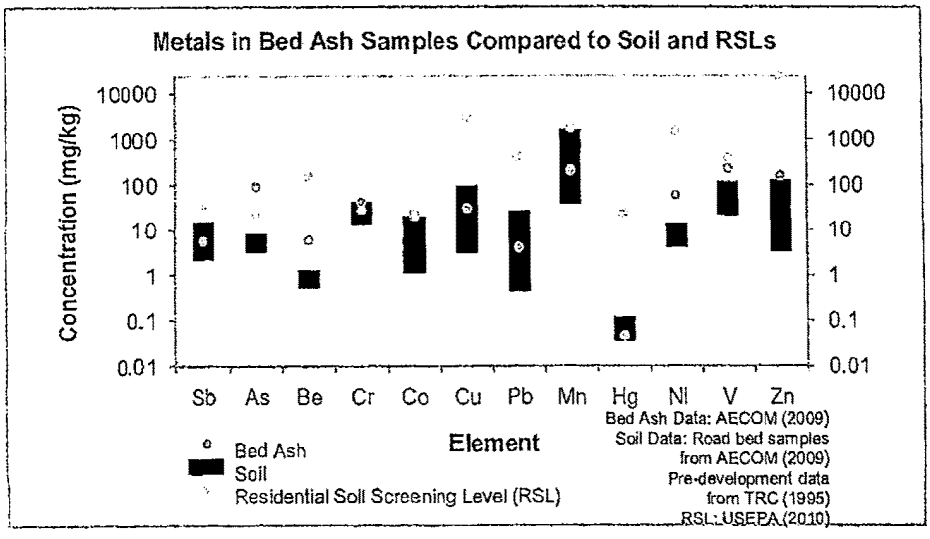



Figure 5
Comparison of TCLP Metals in Soil and Ashes to Toxicity Characteristic Standards
AES Puerto Rico, LP
Guayama, PR